

A Search for Chemical Signatures of Galactic Mergers

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Abstract: We present preliminary chemical abundance analyses of a group of high-velocity metal-poor stars. This report describes our work in progress. We examine the derived abundances in the context of previous studies of metal-poor stars with unusual abundances and/or extreme galactocentric orbits. Included in this sample are BD+80 245, a star previously known to have unusually low α -element abundances, and G4-36, a new low- α star.

1 Overview

A number of very high-velocity metal-poor field stars have been discovered that have very unusual ratios of alpha-elements to iron. The stars discovered to date all have large apogalacticon distances, and so the unusual abundance ratios may suggest a chemical “signature” of previous merger or accretion events. That is, these stars may have originated within a satellite galaxy or galaxies that experienced a different nucleosynthetic chemical evolution history than the Milky Way and which were later accreted by it.

We have observed a sample of over two dozen high-velocity metal-poor field stars using high resolution echelle spectrographs at the KPNO, CTIO, and McDonald Observatories. The stars were selected from Ryan & Norris (1991), Carney *et al* (1994), as well as unpublished studies yielding private catalogs of metal-poor stars. So far, we have analysed the more metal-poor stars and, for those stars in common with previous studies, we obtain results that agree well with those in the literature. Included in our study are a re-analysis of BD+80 245, a star previously known to have low α -element ratios (Carney *et al* 1997) and G4-36, a new low- α star discovered by James (1998).

2 BD+80 245: re-analysis of the “discovery” star

Carney *et al* (1997) reported the discovery of an α -element poor star as a result of their search for low-metallicity disk stars. We have since acquired new spectra of the star, with a resolution of 60,000 and a SNR of ~ 200 . We have independently re-derived the abundances, using a

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Value	Teff	log g	v_{micro}	[FeI/H]	[FeII/H]	n(Li)
Old	5400	3.20	1.50	-1.86	-1.96	1.75
New	5425	3.25	1.35	-1.85	-1.86	1.36

Table 1: A Comparison of Previous and New Values Derived for BD+80 245

	O	Na	Mg	Al	Si	Ca	Sc	Ti	Cr	Mn	Ni	Ba
Old	+0.39	...	-0.31	-0.30	...	-0.26	-1.84
New	...	-0.49	-0.21	-1.31	-0.07	-0.22	-0.26	-0.26	-0.13	-0.13	-0.10	-1.68

Table 2: Previous and New [el/Fe] Results for BD+80 245

different linelist, and largely confirm the previous analysis, as well as expand the abundance list to include additional key elements.

3 G4-36: a star of low Na, Mg, Ca, but high Ni

Among our observations, we included a star of unusual abundances discovered by James (1998). In addition to confirming the unusually low Na, Mg, Ca and Ba abundances determined by James (PhD Thesis in preparation, Univ. of Texas), we find significantly enhanced Ni. This is contrary to the results of Nissen & Schuster who found that the abundances of Ni to be strongly correlated with Na in their low- α stars.

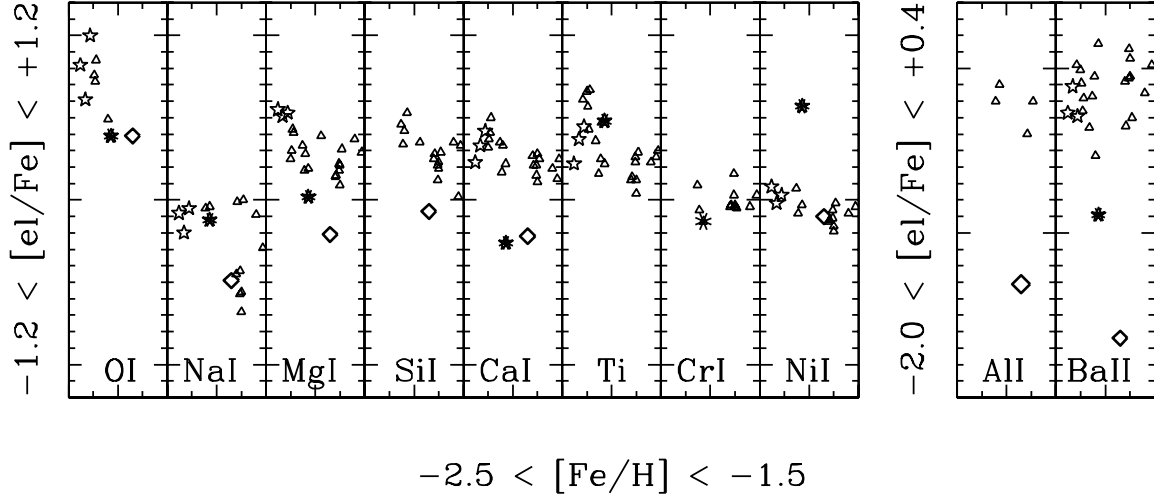


Figure 1: The mean abundances [el/Fe], relative to the solar values, of a number of elements in stars with metallicities similar to those of G4-36 and BD+80 245. The abscissa for each section covers the range $-2.5 < [\text{Fe}/\text{H}] < -1.5$. Note that the plots on the left and the right are scaled to illustrate the same relative ranges in abundance. In order to provide a context for some of the unusual abundances we derived in this study for G4-36 (*) and BD+80 245 (◇), we show the results of other stars (*) of this study, as well as those from Gratton & Snenen (1988), Magain (1989), Carney *et al* (1997), Stephens (1999), and other stars of Rapo $> 15\text{kpc}$, as compiled by Carney *et al* (1997) (△).

4 Na vs. Ni

As previously found by Nissen & Schuster (1997), for most of the stars, there appears to be a good correlation between Na and Ni abundances with respect to iron. As seen in figure 2, this correlation is also found in the Stephens (1999) data. However, a few exceptions stand out: the low globular cluster abundances found by Brown *et al* (1997) for Rup 106 and Pal 12; the unusual star BD+80 245 found by Carney *et al* (1997); as well as BD+24 1676, a star which seems to show mild enhancements in Mg, Ca, and Ti with respect to its iron abundance. Including G4-36, yet another star of interesting abundance ratios, these “unusual” stars seem to fit together, and correspond to a Ni/Na correlation as well, albeit a very different one from the rest of the stars. Whether this is a real correlation, or simply a coincidence imposed by the small number of stars analysed so far, will be determined as the remainder of our two-dozen high velocity star sample is analysed. However, if the secondary correlation exists, a Ni/Na discriminant such as this could be extremely useful as a proxy indicator to target stars of other unusual abundance ratios, thus alerting us to their different nucleosynthetic histories.

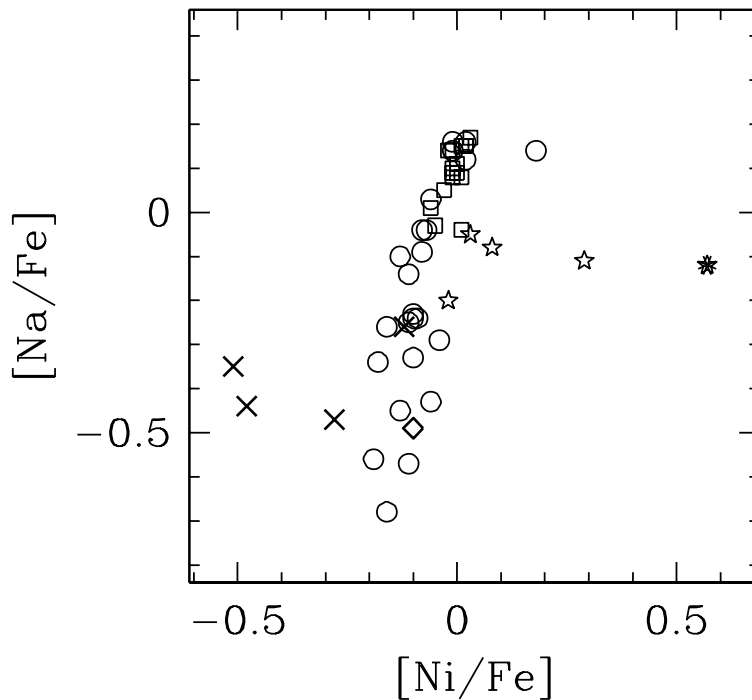


Figure 2: $[\text{Na}/\text{Fe}]$ vs. $[\text{Ni}/\text{Fe}]$. We plot the results of G4-36 (*) and BD+80 245 (\diamond) and the other stars of this study (*) in the context of the halo stars (\circ) and disk stars (\square) studied by Carney *et al* (1997), Nissen & Schuster (1997), and Stephens (1999), as well as the globular cluster stars (\times) studied by Brown *et al* (1997). The overall correlation was observed by Nissen & Schuster (1997) and the results of Stephens (1999) fit this well. However, there are some points belonging to stars of unusual abundance ratios, that do not fit the main trend but, rather, could be fit by another slope.

5 Possible Correlations with Kinematics

The abundances of α - and iron-peak elements as a function of the iron abundance do show abundance trends but, these trends are for the halo stars only. Most of the disk star abundances

are constant across the almost 3 dex range in metallicity. While no abundance trends are observed as a function of eccentricity, there does appear to be a larger scatter in the abundances with increasing eccentricity. This is consistent with the relationship of the α - and iron-peak elemental abundances with the iron abundance: stars defined as members of the disk population have less scatter in the derived abundances. A quantitative estimate of the scatter as a function of the kinematics will be derived once the abundance determinations have been made for our complete sample (for instance, our initial analyses suggest that the scatter in the abundances of α - and iron-peak elements as a function of the predicted perigalactocentric distances are larger for stars that get closer to the centre of the galaxy). Upon completion of the abundance analyses for the entire sample, we will also investigate whether the unusual $[\alpha/\text{Fe}]$ ratios have been found in a large enough sample of stars to identify the kinematics of the progenitor galaxy or galaxies.

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